CLAIMS

What is Claimed is:

1. A method for forming a microelectronic spring structure, the method comprising:

depositing a layer of sacrificial material over a substrate;

forming at least one molding surface in the sacrificial material;

depositing a layer of resilient material over the at least one molding surface of the sacrificial material;

patterning the resilient material to define a spring structure in the at least one molding surface; and

removing at least a portion of the sacrificial material under the spring structure.

2. The method according to Claim 1, wherein said forming step further comprises making an opening through the sacrificial material to a contact surface on the substrate, wherein the at least one molding surface includes at least a portion of the contact surface.

3. The method according to Claim 1, wherein said first depositing step further comprises forming a first sacrificial layer over the substrate and forming at least one additional sacrificial layer over the first sacrificial layer, so that the layer of sacrificial material comprises a plurality of sacrificial layers.

4. The method according to Claim 1, wherein said first depositing step further comprises depositing the layer of sacrificial material comprised of a material selected from the group consisting essentially of polymethylmethacrylates, polycarbonates, polyurethanes, ABS plastics, photoresists, novolac resins, epoxies and waxes.

5. The method according to Claim 1, wherein said forming step further comprises removing a selected portion of the sacrificial material from the substrate.

6. The method according to Claim 1, wherein said first depositing step further comprises applying a curable material onto the substrate.

7. The method according to Claim 6, wherein said applying step further comprises applying the curable material comprised of a material selected from the group consisting of polymethylmethacrylates, photoresists, photopolymers, novolac resins, and epoxies.

8. The method according to Claim 6, wherein said forming step further comprises forming a recess in an upper surface of the curable material, the recess defining the at least one molding surface.

9. The method according to Claim 6, further comprising curing the material to hardness after said forming step.

10. The method according to Claim 6, wherein said forming step further comprises displacing a portion of the curable material.

11. The method according to Claim 10, wherein said forming step further comprises pressing a stamping tool into an upper surface of the curable material.

12. The method according to Claim 1, wherein said forming step further comprises performing an anisotropic etch of the sacrificial material.

13. The method according to Claim 2, wherein said making an opening step further comprises performing an anisotropic etch.

14. The method according to Claim 2, wherein said making an opening step further comprises performing an isotropic etch.

15. The method according to Claim 1, wherein said second depositing step further comprises depositing a mass of metallic material over the at least one molding surface.

16. The method according to Claim 1, wherein said second depositing step further comprises depositing the resilient material through a patterned mask.

17. The method according to Claim 1, further comprising depositing a seed layer of electrically conductive seed material onto the at least one molding surface prior to said second depositing step.

18. The method according to Claim 17, wherein said step of depositing a seed layer further comprises sputtering the seed layer onto the at least one molding surface.

19. The method according to Claim 17, wherein said step of depositing a seed layer further comprises depositing the electrically conductive seed material comprised of a material selected from the group consisting of titanium, chromium, gold, copper, palladium, tungsten, silver, and alloys thereof.

20. The method according to Claim 17, wherein said step of depositing a seed layer further comprises sputtering gold.

21. The method according to Claim 17, wherein said step of depositing a seed layer further comprises sputtering copper.

22. The method according to Claim 17, wherein said step of depositing a seed layer further comprises depositing the seed layer to a thickness in the range of about 100 to 1000 Å.

23. The method according to Claim 17, wherein said step of depositing a seed layer further comprises depositing the seed layer to a thickness in the range of about 1000 to 30000 Å.

24. The method according to Claim 17, wherein said step of depositing a seed layer further comprises depositing the electrically conductive seed material through a patterned mask.

25. The method according to Claim 1, wherein said second depositing step further comprises depositing the layer of resilient material using a process selected from the group consisting of: deposition from aqueous solutions, electrolytic plating, electroless plating, chemical vapor deposition, physical vapor deposition, spin coating, and deposition through induced disintegration of precursors including liquid phase, solid phase, and gaseous phase precursors.

26. The method according to Claim 1, wherein said second depositing step further comprises depositing the layer of resilient material, wherein the layer of resilient material is electrically conductive.

27. The method according to Claim 1, wherein said second depositing step further comprises depositing the layer of resilient material comprised of a material selected from the group consisting of: nickel, and alloys thereof; copper, cobalt, and iron, and alloys thereof; gold and silver; elements of the platinum group and alloys thereof; noble metals; semi-noble metals and alloys thereof, elements of the palladium and alloys thereof; and refractory metals and alloys thereof, tungsten, molybdenum and alloys thereof; and tin, lead, bismuth, indium and gallium, and alloys thereof.

28. The method according to Claim 1, wherein said second depositing step further comprises depositing the resilient material comprising a plurality of material layers, wherein at least one of the plurality of layers comprises a metallic material.

29. The method according to Claim 1, wherein said second depositing step further comprises depositing the resilient material comprising a plurality of material layers, wherein at least one of the plurality of layers comprises an electrically insulating material.

30. The method according to Claim 1, wherein said first depositing step further comprises depositing the sacrificial layer comprised of a thermoplastic material.

31. The method according to Claim 30, wherein said first depositing step further comprises depositing the thermoplastic material comprised of a material selected from the group consisting of polymethylmethacrylates, polycarbonates, polyurethanes, ABS plastics, and waxes.

32. The method according to Claim 30, wherein said forming step further comprises heating the thermoplastic material and forming a recess in an upper surface of the thermoplastic material, the recess defining the at least one molding surface.

33. The method according to Claim 32, further comprising cooling the thermoplastic material to harden after said forming step.

34. The method according to Claim 32, wherein said forming step further comprises displacing a portion of the thermoplastic material.

35. The method according to Claim 32, wherein said forming step further comprises pressing a stamping tool into an upper surface of the thermoplastic material.

36. The method according to Claim 32, wherein said heating step further comprises heating the substrate.

37. The method according to Claim 32, wherein said heating step further comprises pressing a heated stamping tool into an upper surface of the thermoplastic material.

38. The method according to Claim 32, wherein said applying step further comprises applying the thermoplastic material comprised of at least one layer of a dry film photoresist material, and wherein said heating step further comprises heating the photoresist material to a temperature in the range of about 60 to 120 °C.

39. The method according to Claim 38, wherein said forming step further comprises pressing a stamping tool into an upper surface of the thermoplastic material sufficient to provide a pressure toward and normal to the upper surface of the thermoplastic layer in the range about 10 to 1000 pounds per square inch.

40. The method according to Claim 2, wherein said making an opening step further comprises performing an etch according to a process selected from the group consisting of photolithography, plasma etch, wet chemical etch, and combinations thereof.

41. The method according to Claim 2, wherein said making an opening step further comprises exposing an area of the substrate surface in the range about 10^2 square microns to 10^6 square microns.

42. The method according to Claim 39, wherein said making an opening step further comprises exposing an area of the substrate surface of at least about 30,000 square microns.

43. The method according to Claim 1, further comprising treating a surface of the sacrificial material polymer with a plasma to render it electrically conductive, whereby the sacrificial material can serve as a seed layer.

44. The method according to Claim 1, wherein said forming step further comprises contouring a portion of the at least one molded surface in a direction perpendicular to the substrate.

45. The method according to Claim 44, wherein said contouring step further comprises forming a contour in a direction across a width of a beam portion of the spring structure defined in said pattering step.

46. The method according to Claim 45, wherein said contouring step further comprises forming the contour comprising a curve selected from the group consisting of: a U-curve, a V-curve, an S-curve, a T-curve, a L-curve, and a line folded to provide at least one protruding rib.

47. The method according to Claim 44, wherein said contouring step further comprises forming a contour in a direction along a length of a beam portion of the spring structure defined in said pattering step.

48. The method according to Claim 47, wherein said contouring step further comprises forming the contour comprising a curve selected from the group consisting of: an S-curve, a convex curve, a concave curve, and a sinusoidal curve.

49. The method according to Claim 1, wherein said patterning step further comprises defining the spring structure having a projected shape in a plane parallel to a surface of the substrate, the projected shape comprising a base end, a tip end, and a continuous length between the base end and the tip end.

50. The method according to Claim 49, wherein said patterning step further comprises defining the projected shape comprising a shape selected from the group consisting of: a triangle, a rectangle, an L-shape, a U-shape, a C-shape, a J-shape, a spiral, a square wave, and a sinusoid.

51. The method according to Claim 49, wherein said patterning step further comprises defining the projected shape comprising at least a portion having parallel arms.

52. The method according to Claim 49, wherein said patterning step further comprises defining the projected shape comprising a shape wherein a shortest distance between the base end and the tip end is less than the continuous length between the base end and the tip end.

53. The method according to Claim 1, wherein said forming step further comprises forming at least one recess in the sacrificial material, partially filling the at least one recess with a fluid presenting a meniscus shape, and stabilizing the meniscus shape, wherein at least a portion of the molding surface is defined by the meniscus shape.

54. The method according to Claim 53, wherein said partially filling step further comprises partially filling the at least one recess with the fluid comprised of a photoresist material.

55. The method according to Claim 53, wherein said step of forming the at least one recess further comprises forming a recess having a projected shape in a plane parallel to a surface of the substrate, the projected shape comprising a base end, a tip end, and a tapered portion between the base end and the tip end, wherein the tapered portion tapers from a first width adjacent to the base end to a second, narrower width adjacent to the tip end.

56. The method according to Claim 1, wherein said forming step further comprises:

impressing a primary tooth into the layer of sacrificial material, thereby forming a first portion of the at least one molding surface; and then

impressing a secondary tooth into the layer of sacrificial material, thereby forming a second portion of the at least one molding surface.

57. The method according to Claim 56, wherein said second impressing step further comprises forming an overhanging lip comprising the second portion of the at least one molding surface.

58. The method according to Claim 56, further comprising selecting the primary tooth and the secondary tooth located on separate stamping tools.

59. The method according to Claim 1, wherein said first depositing step further comprises depositing the layer of sacrificial material comprised of an electrically conductive material.

60. The method according to Claim 1, wherein said forming step further comprises forming a recess in an upper surface of the layer of sacrificial material, the recess defining the at least one molding surface and sidewalls separating the at least one molding surface and the upper surface of the layer of sacrificial material.

61. The method according to Claim 60, wherein said depositing step further comprises depositing the layer of resilient material using a line-of-sight deposition method.

62. The method according to Claim 61, wherein said patterning step comprises removing the layer of resilient material from the sidewalls.

63. The method according to Claim 61, wherein said patterning step comprises providing the sidewalls inclined with respect to a line of deposition of the line-of-sight deposition method so as to not present a face for deposition of the layer of resilient material, whereby the layer of resilient material is patterned during said depositing step.

64. The method according to Claim 61, further comprising plating a second layer of resilient material onto the layer of resilient material over the at least one molding surface.

65. The method according to Claim 1, wherein said forming step further comprises forming a molding surface including a portion for molding a redistribution trace integral with the microelectronic spring structure.

66. The method according to Claim 1, wherein said molding step further comprises forming a molding surface including a bump for molding a stop structure.

67. The method according to Claim 1, wherein said forming step further comprises forming the at least one molding surface using a plunge EDM tool, wherein the sacrificial material is electrically conductive.